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Health and Environmental Effects Profile for Terbufos

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HEALTH AND ENVIRONMENTAL EFFECTS PROFILE FOR TERBUFOS

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16. ABSTRACT

The Health and Environmental Effects Profile for Terbufos was prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Solid Waste to support listings of hazardous constituents of a wide range of waste streams under Section 3001 of the Resource Conservation and Recovery Act (RCRA). Both published literature and information obtained from Agency program office files were evaluated as they pertained to potential human health, aquatic life and environmental effects of hazardous waste constituents.

Quantitative estimates have been presented provided sufficient data are available. Terbufos has been determined to be a systemic toxicant. An Acceptable Daily Intake (ADI), defined as the amount of a chemical to which humans can be exposed on a daily basis over an extended period of time (usually a lifetime) without suffering a deleterious effect, for Terbufos is 1×10^{-4} (mg/kg bw/day) for oral exposure.

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PREFACE

Health and Environmental Effects Profiles (HEEPs) are prepared for the Office of Solid Waste by the Office of Health and Environmental Assessment. The HEEPs are intended to support listings of hazardous constituents of a wide range of waste streams under Section 3001 of the Resource Conservation and Recovery Act (RCRA). Both published literature and information obtained from Agency program office files are evaluated as they pertain to potential human health, aquatic life and environmental effects of hazardous waste constituents. The literature searched and the dates of the searches are included in the section titled "Appendix: Literature Searched."

Quantitative estimates are presented provided sufficient data are available. For systemic toxicants, these include, Acceptable Daily Intakes (ADIs) for chronic exposures. An ADI is defined as the amount of a chemical to which humans can be exposed on a daily basis over an extended period of time (usually a lifetime) without suffering a deleterious effect. In the case of suspected carcinogens, ADIs are not estimated in this document series. Instead, a carcinogenic potency factor or q_1^* is provided. These potency estimates are derived for both oral and inhalation exposures where possible. In addition, unit risk estimates for air and drinking water are presented based on inhalation and oral data, respectively.

The first draft of this document was prepared by Syracuse Research Corporation under EPA Contract No. 68-03-3228. The document was subsequently revised after reviews by staff within the Office of Health and Environmental Assessment: Carcinogen Assessment Group, Reproductive Effects Assessment Group, Exposure Assessment Group, and the Environmental Criteria and Assessment Office in Cincinnati.

The HEEPs will become part of the EPA RCRA docket.

ACKNOWLEDGEMENTS

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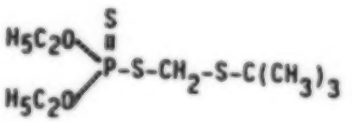
LIST OF ABBREVIATIONS

BCF	Bioconcentration factor
LC_{50}	Concentration lethal to 50% of recipients
LD_{50}	Dose lethal to 50% of recipients
NOEL	No-observed-effect level
ppm	Parts per million
TLV	Threshold limit value

1. INTRODUCTION

1.1. STUCTURE AND CAS NUMBER

Terbufos is the common name for S-tert-butylthiomethyl O,O-diethylphosphorodithioate. It is also known as phosphorodithioic acid, S-[[(1,1-dimethyl-ethyl)thio]methyl]O,O-diethyl ester (BCPC, 1977). This insecticide was introduced by American Cyanamid Company under the code number AC 92,100 and trademark "Counter" (BCPC, 1977). This product has been marketed since January, 1975 (SRI, 1976). The structure of terbufos is depicted below:



The molecular formula of terbufos is $C_9H_{21}O_2PS_3$ and the molecular weight is 288.45. The Chemical Abstract Services (CAS) number for this compound is 13071-79-9.

1.2. PHYSICAL AND CHEMICAL PROPERTIES

Terbufos is a clear, colorless to pale yellow liquid, which is soluble in water, acetone, alcohols, aromatic hydrocarbons and chlorinated hydrocarbons. It decomposes on prolonged heating at temperatures >120°C or in the presence of strong acids (pH <2) and alkalies (pH >9) (BCPC, 1977). Some of the physical properties of terbufos are listed below (BCPC, 1977).

Boiling point:	69°C at 0.01 mm Hg
Melting point:	-29.2°C
Vapor pressure:	2.6×10^{-4} mm Hg at 25°C 1.0×10^{-3} mm Hg at 42°C 2.4×10^{-3} mm Hg at 76°C
Solubility:	10-15 mg/l

1.3. PRODUCTION DATA

Terbufos is prepared by the reaction of phosphorus pentasulfide with diethyl phosphorodithioic acid (SRI, 1976). It is produced by American Cyanamid Company in Hannibal, MO (SRI, 1983). The current United States production of this chemical was unavailable, but in 1976, 1 million pounds were manufactured, and an expansion in capacity was planned for 1977 (SRI, 1976). (See Appendix for literature searched; also additional classified information is available. See Chapter 8 for a more complete explanation.)

1.4. USE DATA

Terbufos has effective initial and residual activity against soil insects. Soil application of terbufos controls maize rootworm larvae, sugar beet maggot, cabbage maggot, onion maggot and wireworms (BCPC, 1977).

2. ENVIRONMENTAL FATE AND TRANSPORT PROCESSES

Terbufos is applied directly to soil to control insects; therefore, its fate and transport in the environment have been well characterized. It has been determined that terbufos undergoes oxidation in soils to form terbufos sulfoxide and then to terbufos sulfone (Jamet and Piedallu, 1978; Chapman et al., 1982; Felsot et al., 1982; Laveglia and Dahm, 1975; Chapman and Harris, 1980). The rate of oxidation in soil was found to increase with increasing temperature and decreasing organic matter content and pH. Laveglia and Dahm (1975) measured a half-life of 4-5 days for terbufos in three soils at 22°C (pH 5.7-7.0; 2.8-4.2% organic matter content). The rate of oxidation increased as the pH and content of organic matter decreased. Felsot et al. (1982) compared the rate of oxidation in eight soil types. In general, the rate was faster in soils containing <2% organic carbon. In addition, the rate of oxidation increased with increasing temperature. For example, at temperatures of 6, 25 and 35°C, the half-life of terbufos in a sandy loam soil (1.16% organic matter, pH 6.0) was 38, 9.4 and 6 days, respectively, compared with 100, 22 and 16 days, respectively, in a soil with 3.5% organic matter and a pH of 7.1. Ahmad et al. (1979) measured a half-life of 11-12 days for terbufos under field conditions (2.6-3.4% organic matter and pH 7.1-8.0); for soil exposed to simulated rain in the laboratory, Jamet and Piedallu (1978b) measured a half-life of 24 days for the disappearance of ^{14}C-terbufos.

Residues of terbufos and its two metabolites, terbufos sulfoxide and terbufos sulfone, were more persistent in a muck soil than in a sand soil under field conditions (Chapman and Harris, 1980). In the sand soil, terbufos disappeared quickly, with 95% lost in ~7 weeks. Volatilization may have been a major factor as a small amount of the parent compund (~20%) was con-

verted to terbufos sulfoxide. Oxidation of the sulfoxide to terbufos sulfone was limited in this experiment, with the highest concentration detected representing only 2.8% of the initial terbufos application. One year after treatment with 3.4 kg/ha, the residues of the three chemicals present in the soil comprised 3.3% of the initial application and after 2 years residues declined to 1.2% (Chapman and Harris, 1980). Initial disappearance of terbufos in the muck soil was also rapid (95% in ~2 weeks), with much larger amounts converted to terbufos sulfoxide (67% of initial application within 8 weeks) and terbufos sulfone (18.4% after 52 weeks). Terbufos residues were relatively persistent, with 42% of the three residues present in the soil after 24 weeks. One year after treatment, 41% of the initial application was still present, for the most part as terbufos sulfoxide and terbufos sulfone, and 2 years after treatment, 5.6% was present as the metabolites (Chapman and Harris, 1980).

Chapman et al. (1982) compared the rate of oxidation of terbufos to terbufos sulfoxide in natural and sterilized soils at 28°C. Oxidation to the sulfoxide proceeded in the sterilized soils but at a reduced rate (1/5 to 1/3 of the rate in natural soils), and oxidation of the sulfoxide to the sulfone was not observed. These data indicate that microbial activity was partially responsible for the transformation of terbufos and its oxidation products.

The processes that will influence the transport of terbufos in soil are volatilization and leaching. The extent of adsorption between the insecticide molecules and the soil complex will affect both processes. Felsot et al. (1982) measured the extent of adsorption of terbufos in eight soils (pH 5.1-7.2; organic carbon content 0.43-16.8%). The authors reported that, in general, terbufos adsorption constants (Freundlich) increased (4.5-87.2)

with increasing organic carbon content. In two of the soils tested, adsorption constants were not well correlated with the content of organic matter. Two possible explanations were provided for this phenomenon. First, it was suggested that the bulky tertiary-butyl group of terbufos hindered adsorption on the inner surfaces of organic matter. A second explanation may be that the soils with higher organic carbon contents were not depleted in nutrients as quickly as soils with lower or moderate organic matter under laboratory conditions; therefore, a relatively more active microbial population would exist in high organic soils that would cause more rapid metabolism of the compound. Jamet and Piedallu (1978a) reported that adsorption of terbufos in four soils increased with increasing organic matter content; however, few details of this study were provided in the abstract. Kenaga (1980) calculated a log soil sorption coefficient of 3.04 for terbufos from binary regression equations, which suggests that the compound has a relatively high sorption potential.

Although no data were available that measured the rate of volatilization of terbufos from soils, Chapman and Harris (1980) and Chapman et al. (1982) attributed an initial loss of terbufos from sandy soils to rapid volatilization. It can be speculated, therefore, that volatilization of terbufos may occur more rapidly from soils low in organic matter due to the decreased adsorption of the insecticide to the soil particles.

Jamet and Piedallu (1978a,b) reported that terbufos and its metabolites displayed low mobility and poor leaching in 4 soils, and Felsot et al. (1982) recovered >90% of terbufos from the top 10 cm of a soil profile from the field located columns, indicating that the compound was not subjected to much leaching.

Little data regarding the fate and transport of terbufos in the aquatic environment were located in the available literature. Bowman and Sans (1982) reported that terbufos disappeared rapidly (half-life = 3 days) in sterilized, natural and distilled water (pH 6.0-8.8; 20°C), indicating that chemical degradation predominated. The sulfoxide and sulfone were more persistent in the distilled water (half-life = 280-350 days) than in the natural water (half-life = 18-40 days), suggesting that microbial degradation may be more important in the disappearance of the oxidation products.

Limited data describing the transport of terbufos in the aquatic environment were available. Belluck and Felsot (1981) measured a log BCF of 10 for terbufos in egg masses of the caddisfly. This factor may be underestimated due to the gelatinous nature of the egg masses, which may have inhibited absorption of the compound. Two log octanol-water partition coefficients of 4.17 (Belluck and Felsot, 1981) and 2.22 (Rao and Davidson, 1982) suggest that this compound may bioaccumulate in aquatic organisms. It should be noted that a number of regression equations listed by Lyman et al. (1982) for this type of compound based on aqueous solubility yielded log K_{ow} values >4.00.

Data regarding the fate and transport of terbufos in the atmospheric environment were not located in the available literature; however, some inferences can be made based on its physical properties. The compound may enter the atmosphere as a result of spray drift during application or volatilization from soil. Due to the relatively high potential for sorption to particulate matter and the relatively low solubility in water, terbufos may be removed from the atmosphere through dry deposition.

3. EXPOSURE

STORET contained observations from 32 stations for total (water and sediment) concentrations of terbufos in surface and groundwaters in Minnesota, Iowa, Ohio, Illinois and Michigan. The overall analysis for terbufos in ground and surface waters ranged from 0-2.25 µg/ℓ with a mean of 0.06886 µg/ℓ. Concentrations of terbufos were <0.2 µg/ℓ for springs and wells, <0.1 µg/ℓ for lakes and from 0-2.25 µg/ℓ for streams.

4. PHARMACOKINETICS

4.1. ABSORPTION

Pertinent data regarding the absorption of terbufos by mammals could not be located in the available literature.

4.2. DISTRIBUTION

Pertinent data regarding the tissue distribution of terbufos could not be located in the available literature.

4.3. METABOLISM

Terbufos is an organophosphate and may, therefore, be assumed to undergo reactions typical of this class of compounds. Thus, oxidation of the thiono moiety to yield an oxo group is presumably required for activation and the production of anticholinesterase action. Inactivation probably involves oxidative dealkylation (Casarett and Doull, 1975).

Limited information is available on the metabolism of terbufos. Hajjar and Hodgson (1980) have reported that terbufos is oxidized at the thioether sulfur atom by a flavin adenine dinucleotide-dependent monooxygenase in pig liver microsomes. Wei and Felsot (1982) identified the major metabolites of terbufos in soil as terbufos sulfoxide, terbufos sulfone, terbufoxon (the major bioactive metabolite), terbufoxon sulfoxide and terbufoxon sulfone. They imply that these metabolites are also found in mice.

4.4. EXCRETION

Pertinent data regarding the excretion of terbufos could not be located in the available literature.

5. EFFECTS

5.1. CARCINOGENICITY

Pertinent data regarding the carcinogenicity of terbufos could not be located in the available literature. Terbufos is not scheduled for testing by the National Toxicology Program (NTP, 1983).

5.2. MUTAGENICITY

Gentile et al. (1982) tested terbufos for mutagenicity in Salmonella typhimurium strains TA1535, TA1537, TA1538, TA98 and TA100, and Saccharomyces cerevisiae strain D4. Negative results were obtained in the bacterial assays, both with and without rat liver S9 or maize S1 fractions. In the yeast assay, both commercial and technical grades of terbufos were mutagenic in the absence of an activating system. The maximum effect was observed at a dose of 33 µg/plate (dose range not specified). Only the technical grade product was mutagenic in the presence of rat liver S9 and neither product was mutagenic in the presence of the maize S1 fraction.

5.3. TERATOGENICITY

No information on the teratogenicity of terbufos could be located in the available literature. In studies available to the U.S. EPA, but not located in the published literature, negative results were reported in rats at a dose of 0.15 mg/kg. Unspecified effects were noted at 1 ppm in a 3-generation reproduction study in rats (47 FR 17058). (See Appendix for literature searched; also additional classified information is available. See Chapter 8 for a more complete explanation.)

5.4. OTHER REPRODUCTIVE EFFECTS

Other than the 3-generation rat study mentioned in Section 5.3, no data on other possible reproductive effects could be located in the available

literature. (See Appendix for literature searched; also additional classified information is available. See Chapter 8 for a more complete explanation.)

5.5. CHRONIC AND SUBCHRONIC TOXICITY

Pertinent data regarding the chronic and subchronic toxicity of terbufos could not be located in the available literature.

The U.S. EPA has studies available which indicate a NOEL for cholinesterase inhibition and systemic toxicity of 0.0025 mg/kg/day (0.1 ppm) in dogs based on a 6-month feeding study, and a NOEL for effects on red blood count and brain cholinesterase of 0.25 ppm in rats based on a 90-day feeding study. A delayed neurotoxicity study in chickens (0.01 mg/kg) also produced negative results (47 FR 17058). These studies were not located in the published literature. Martin and Worthing (1977) refer to long-term feeding studies in dogs (6 months), mice (18 months) and rats (24 months) in which no adverse effects, other than those associated with cholinesterase depression, were noted; however, no references were given and the studies are presumably proprietary. (See Appendix for literature searched; also additional classified information is available. See Chapter 8 for a more complete explanation.)

5.6. OTHER RELEVANT INFORMATION

Wei and Felsot (1982) reported an acute oral LD_{50} of 3.5 mg/kg in male mice. Martin and Worthing (1977) reported acute oral LD_{50}s of 1.6-4.5 mg/kg in male rats, 9.0 mg/kg in female rats and 5.0 mg/kg for female mice. Dermal LD_{50}s were reported for rats (1.0 mg/kg) and rabbits (7.4 mg/kg). When formulated as granules, the dermal LD_{50} ranged from 230->20,000 mg/kg. McCann et al. (1981) determined the LC_{50} of terbufos in the diets (5 days) of Wistar rats. They reported an LC_{50} of 26.4 ppm for technical grade terbufos.

6. AQUATIC TOXICITY

Pertinent data regarding the acute or chronic toxcity of terbufos on aquatic plants or animals could not be located in the available literature. Belluck and Felsot (1981) reported that terbufos and possible metabolites at 0.10 mg/ℓ during 120 hours of study concentrated to slightly >1.0 mg/ℓ (BCF ~10) in eggs of the caddisfly, Triaenodes tardus. The impact of terbufos exposure and bioconcentration on egg survival was not investigated. Additional information on the effects of terbufos in the aquatic environment could not be located in the available literature.

7. EXISTING GUIDELINES AND STANDARDS

7.1. HUMAN

The ACGIH has not established a TLV for terbufos (ACGIH, 1980, 1982). The U.S. EPA has established a tolerance of 0.05 ppm for residues on corn intended for human consumption (40 CFR 180.352).

7.2. AQUATIC

Guidelines and standards for the protection of aquatic organisms from the toxic effects of terbufos were not located in the available literature.

8. RISK ASSESSMENT

The available data are insufficient for the development of a quantitative risk assessment. No carcinogenicity studies were found, mutagenicity data are limited, and although teratogenicity, 3-generation reproduction, subchronic and chronic toxicity studies appear to have been performed (see Section 5.5.), they are not available in the published literature.

Statements concerning available literature in this document refer to published, quotable sources and are in no way meant to imply that confidential data, which this document could not address, are not in existence. These data, which are considered Classified Business Information (CBI), are available in summary form as a CBI Appendix that can be accessed by individuals with appropriate clearance. Conclusions from the CBI Appendix regarding risk assessment can, however, be presented in this chapter.

The CBI Appendix to this document reviews other animal data, from which an ADI of 0.1 µg/kg bw/day, or 7 µg/day for a 70 kg man, was derived. The ADI was based on a NOAEL of 0.01 mg/kg bw/day in a 6-month dog feeding study and an uncertainty factor of 100 [this includes a factor of 10 to account for interspecies extrapolation and another 10 for protection of unusually sensitive individuals within the human population; an additional uncertainty factor for the use of a subchronic study for ADI derivation is unnecessary because of the strongly supportive no-effect levels (0.013 mg/kg bw/day for females and 0.011 for males) determined from a 2-year rat feeding study]. At the next highest level tested (0.042 mg/kg bw/day) male rats had increased mortality.

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APPENDIX: LITERATURE SEARCHED

This profile is based on data identified by computerized literature searches of:

CA SEARCH (Files 308, 309, 310, 311, 320)
TOXLINE
MEDLINE
RTECS
SCI SEARCH
OHM TADS
STORET
SRC Environmental Fate Data Bases
SANSS
AQUIRE

Most of these searches were conducted in July and August 1983. In addition, hand searches were made of Chemical Abstracts (Collective Indices 6 and 7th), and the following secondary sources were reviewed:

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